

# Environmental Protection Agency

## **Hydraulic Tubing Fabrication Procedure**

This procedure is written for the Environmental Protection Agency, National Vehicle and Fuel Emissions Laboratory (NVFEL) internal use. The use of specific brand names by NVFEL in this procedure are for reference only and are not an endorsement of those products. This document may be used for guidance by other laboratories.

### **NVFEL Reference Number**

048

### **Implementation Approval**

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## 1. Purpose

The purpose of this working procedure is to describe the equipment and steps required to perform hydraulic tubing fabrication involving cutting, bending, and flaring using the following equipment:

Thomas Cutting Machine - Model Cut 250,  
Parker Large Exactol Tube Bender - Model 420  
Parker Flaring Machine – Model 1015

References required include:

“Thomas Cut 250 USE AND MAINTENANCE MANUAL”  
“Parker Large EXACTOL Tube Bender Model 420 Bulletin 4391-B16, Revised April 1991”  
“Parker Flaring machine ‘1015’” 4390-B3  
EPA Current Safety Policies

## 2. Test Procedure

### 100 Tube Selection

- 101 Select the proper tubing for flow, pressure and to match the existing tube ends.
- 102 Refer to the chart for pressure listings. See Attachment A, “Hard Tubing Pressure Ratings.”.
- 103 Measure the length of the tubing and location of all bends.

## 200 Cutting Machine Operation

All shields must be in place when the machine is in use.

The machine must be disconnected from the power source before changing a disk or performing maintenance.



Figure 1  
Cutting Machine

- 201 Place the tubing to be cut in the vice and clamp the part into place with the handwheel.
- 202 Turn the switch from “Off” (0) to “On” (1).
- 203 Grip the handle of the control arm and press the trigger. Ensure that the disk is turning properly and that sufficient coolant is being disbursed.  
  
If the saw has not been used for an extended period, or flow is low, add approximately 1 quart of cold water to the base of the unit and run it until the water and fluid mix.
- 204 Cut the tubing slowly using suitable descent of the head to ensure good cutting quality and machine performance.

- 205 When the cut is complete, release the running button, raise the control arm, switch off the machine, and remove the part by reversing the procedure described in Step 201.
- 206 When replacement of the lubricating fluid becomes necessary, use only Trim Sol Aqueous oil solution mixed in a 1:4 ratio with water.

### 300 Tube Bender Operation (-16 tube

**Note:** Thin wall tubing is difficult to bend without flattening. Under this condition, use the internal mandrel.

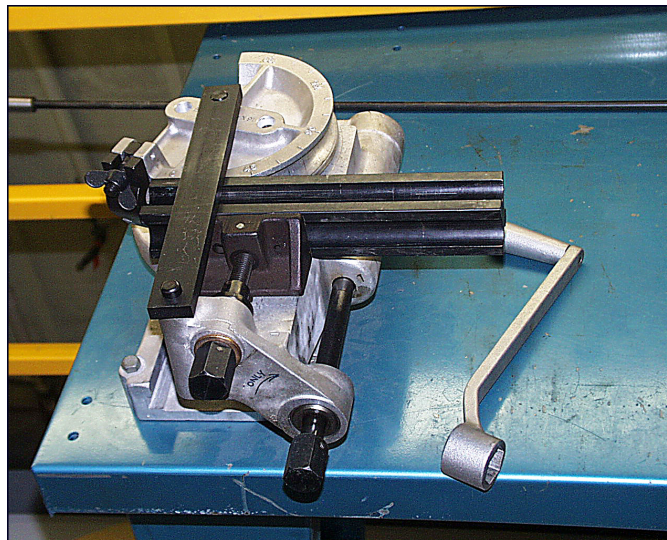


Figure 2  
Tube Bender

- 301 Measure from the tube end to the center line of the first bend. Mark the desired location.
- 302 Position the tube in the bender so that the end measured from is to your left as you face the bender. It should be positioned in the tube clamp of the radius block so that the mark is tangent to the desired degree mark on the radius block. For angles greater than 90°, align the tube as if for a 90° bend, but bend the desired angle. Close the tube clamp and tighten the wing nut to clamp the tube firmly.
- 303 Select the proper groove of slide block for the outside diameter of the tube. The sizes are marked on the end of the sideblock. Position the slide block against the slide block vise face with the end of the block adjacent to the tube clamp of the radius block.

- 304 Lubricate the slide block to facilitate sliding and advance the slide block, by means of the upper adjustment screw, to rest snugly against the tube but not with so much pressure as to prevent the block from sliding easily along the slide block vice face.
- 305 Place the tie bar over the center post and the dowel pin. (Use the tie bar with heavy wall tubing of sizes 7/8 inch or above.)
- 306 Bend the tube by turning the operating the crank in a clockwise direction. The angle of the bend is indicated by the marks on the radius block. At the completion of the bend, the desired degree mark will be in line with the left side of the bender. A slight amount of over-bending is required to account for a spring-back.
- 307 Remove the tie bar, retract the slide block vise, and remove the slide block.
- 308 Loosen the wing nut on the clamp, and open. Pull the tube out from the radius block and lift.
- 309 To reset the bender, turn the worm wheel shaft counterclockwise to disengage. Turn the radius block back until the 0° mark is at the original starting point.

#### 400 Tube Flaring Operation

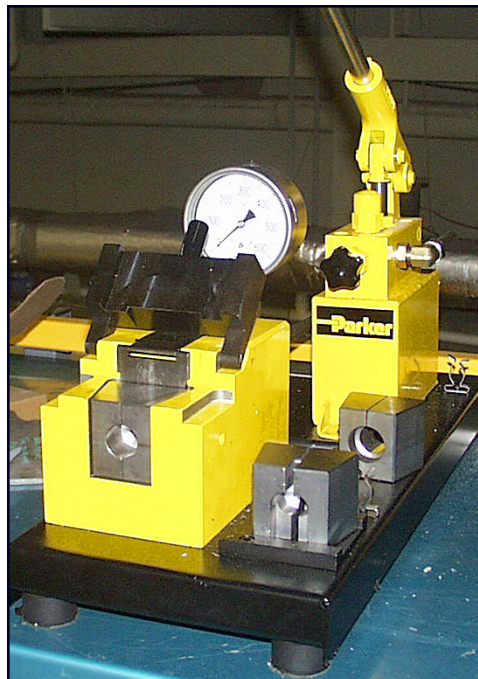


Figure 3  
Flaring Machine

- 401 Cut the tubing square as described in Sections 200 through 206.
- 402 Use the tube reamer to remove any burrs from the inner and outer diameter of the tube to be flared.
- 403 Clear all metal chips from the inside of the tube to approximately 1 diameter deep.
- 404 Apply a single drop of oil to the flaring cone each day the flaring tool is used.
- 405 Ensure that the nut and sleeve are oriented correctly on the tube before flaring.
- 406 Lift the black cover. Place the two flaring dies of the proper size for the selected tubing together in the die set area and push against the locating flap.
- 407 Insert the tube into the dies until it bottoms on the locating flap, then replace the cover. Avoid oil contact on the outside of the tubing, as it may allow the tubing to slip in the dies.
- 408 Keep the tube horizontal for the flaring operation. A long tube may require external support.
- 409 Close the relieve-to-tank valve by turning the hand knob clockwise.
- 410 Pump by hand until the recommended pressure, as shown on the pressure chart on unit or included in attachment B, is realized. The locating flap will rise up.
- 411 Retract the flaring cone by turning relieve-to-tank valve counter-clockwise. Lift the cover into the up position and draw the tube and dies out upwards.
- 412 After flaring, use the die separator located on the right side of the flaring block to remove the tube from the dies by lightly tapping them.
- 413 Thick walled –16 (1 inch) tubing may require a shim placed between the locator flap and the flaring dies to produce a sufficient flare to allow good mating surfaces for the fitting. If a shim is used, the outer edge of the flare may need to be ground down to allow the nut to slide over. The shim is on a rope attached to the flaring machine.
- 414 Clean the tubing with rags, compressed air or parts washer to remove foreign debris before placing in service.

## Attachment A

### Hard Tube Pressure Ratings

Hard Tubing Pressure Ratings <sup>1</sup>							
	OD	Wall Thickness	Stainless 304L	Aluminum 6061-T6	JIC Hyd. Tubing	ID	Flow Area
	in	in	psi	psi	psi	in	in <sup>2</sup>
-4	0.25	0.020	3425			0.210	0.035
	0.25	0.028	4450			0.194	0.030
	0.25	0.035	6325	3400		0.180	0.025
-6	0.375	0.020	2225			0.335	0.088
	0.375	0.035	4050	2175		0.305	0.073
	0.375	0.049	5850			0.277	0.060
-8	0.5	0.020	1650			0.460	0.166
	0.5	0.028	2350	1250		0.444	0.155
	0.5	0.035	2975	1600		0.430	0.145
	0.5	0.065	5825			0.370	0.108
-12	0.75	0.035	1950	1050		0.680	0.363
	0.75	0.083	4875			0.584	0.268
	0.75	0.120	7350			0.510	0.204
-16	1	0.035	1450	775	900	0.930	0.679
	1	0.049	2050			0.902	0.639
	1	0.120	5325			0.760	0.454
-20	1.25	0.035	1150	600		1.180	1.094
	1.25	0.065	2175			1.120	0.985
	1.25	0.120	4175			1.010	0.801

<sup>1</sup> Pressure Ratings are calculated with the Boardm and Lame' formulae, using 4X safety factor, tensile strength=80ksi 304L SS, 43ksi 6061 Al, 51ksi JIC.



## Attachment B

**Recommended Flaring Pressure for Parker 1015 Flaring Machine  
BAR Per Tubing Wall Thickness**

<b>Recommended Flaring Pressure, BAR Per Tubing Wall Thickness</b>										
<b>Size</b>	<b>Material</b>	<b>.020</b>	<b>.028</b>	<b>.035</b>	<b>.049</b>	<b>.065</b>	<b>.083</b>	<b>.095</b>	<b>.109</b>	<b>.120</b>
<b>4</b>	Steel	15	15	15	20	20				
	Stainless Steel	15	15	20	20	25				
<b>6</b>	Steel		40	40	40	40				
	Stainless Steel	40	40	40	50	50				
<b>8</b>	Steel			40	45	60	65			
	Stainless Steel		50	50	55	70	75			
<b>10</b>	Steel			50	70	80	90	90		
	Stainless Steel			60	80	100	100	100		
<b>12</b>	Steel			60	70	80	100	115	130	
	Stainless Steel			70	80	90	120	120	140	
<b>16</b>	Steel			100	100	100	120	120	120	120
	Stainless Steel			110	120	135	135	150	150	150
<b>20</b>	Steel				100	120	120	125	130	140
	Stainless Steel				115	130	130	150	170	180
<b>24</b>	Steel					130	130	135	140	140
	Stainless Steel				120	140	150	200	200	200